

Sea surface temperature (SST) anomalies of the Yellow and East China Seas in July of 2020

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Abstract. With the global warming, the long term variations of sea surface temperature and its anomalies in the Yellow and East China Seas, especially for the July of 2020 due to the abnormally torrential rain along Changjiang/Yangtze River Valley, have been investigated based on the Merged Satellite and In-situ Data Global Daily sea surface temperature (MGDSST) provided by the Japan Meteorological Agency (JMA) using the methods of composite and correlation analyses. The results suggest, contrary to warming anomalies in the North-western Pacifica Ocean, the sea surface temperature in the East China Sea is cooler around 0.5°C and that in the East China Sea is cooler around 1.3°C than the normal values. The sea surface temperatures approach the extreme low value in the Yellow Sea and East China Sea in July, and warm up to the normal year in August. In addition, the south-westerly summer monsoon over this region, is proposed to contribute the transport of Kuroshio and its pathway. The obvious westerly wind anomalies, correspond to the lower sea surface temperature over the Yellow and East China Seas in July of 2020, leads to a clear less heat advection from Kuroshio to this region. Further, the low sea surface temperature, leading a downward air motion with a convergence at near sea surface level, is helpful for the enhance of the westerly wind anomalies until the strong surface heat flux in August. This study suggests that the local horizontal circulation advection and net heat flux are also dominated on the heat content of the East China waters. Further quantitative studies are worth conducting.

1 Introduction

The coastal waters of China (Bohai Sea, Yellow Sea, the East China Sea and the South China Sea) are the important marginal seas of the Western Pacific Ocean. They are located along the south-eastern China Mainland from north to south, spanning temperate zone, subtropical zone and tropical zone. The monsoon and the western boundary current have a significant impact on the coastal water properties, such as the water temperature, salinity and circulation system. The temperature and pressure gradients, which are caused by the thermal difference between land and ocean, are more significant than those in any other sea areas. They are not only affected by land, but also have an important impact on the coastal climate of China. Therefore, it is of great significance to study the changes of marine environmental factors in China's coastal waters.

With the global warming, the average ocean temperature gradually increases, and the warming of sea surface temperature shows inhomogeneity, and the controlling factors of warming in different ocean regions are also different. Frankignoul et al. [1] found that through the heat balance process of the upper ocean, the sea surface temperature is not only affected by the air-sea interface though heat flux, but also can affect the heat flux in return, forming a feedback regulation of sea surface

temperature and heat flux. Liu et al. [2] pointed out that the characteristics of sea surface temperature anomalies in the North Pacific and the variation of the contribution proportion of local factors show that the sea surface heat flux [3] and meridional advection are the main contribution factors of sea surface temperature anomaly in the subtropical basin, and their contributions are consistent.

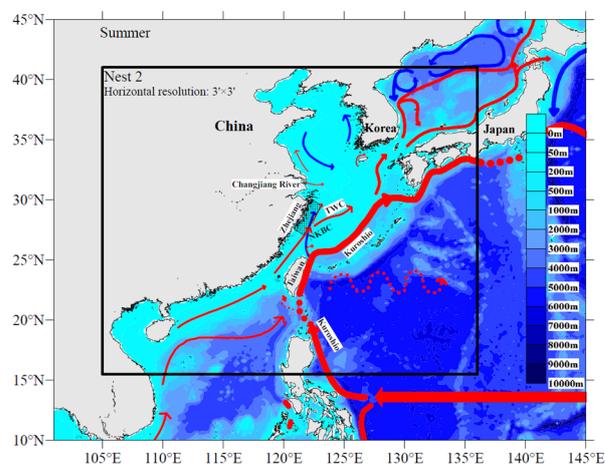


Fig1. Schematic diagram of summer circulation in the China Seas and the adjacent waters (quoted from Yang et al., 2018).

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As pointed by previous studies, the Kuroshio, Taiwan-Tsushima current system (Figure 1) are the most important heat advectons for the Yellow Sea and the East China Sea [4-6]. Thus, the influence of the ocean circulation in the East China Sea and its adjacent coastal waters on the sea surface temperature is studied from the perspective of atmospheric circulation anomalies.

2 Data

2.1 Sea surface temperature data

In order to investigate the long term variations of sea surface temperature and its anomalies in the Yellow and East China Seas, we use the Merged Satellite and In-situ Data Global Daily sea surface temperature (MGDSST), which is provided by the Japan Meteorological Agency (JMA). MGDSST is based on the AVHRR infrared sensors of NOAA, which is same with the Optimum Interpolation Sea Surface Temperature Analysis (OISST) with respect to covering period and spatial resolution. While, in addition, MDSST also combined with in-situ obviations from buoys and ships. And according to the previous study [7], MDGSST performs better the OISST in the Yellow Sea and East China Sea. The horizontal resolution is $0.25^{\circ} \times 0.25^{\circ}$. We select the focusing region (Figure 1) within the limits of 24°N – 40°N , 117°E – 135°E . And the available period is from 1982 until now. Thus, in this study, we chose the monthly mean sea surface temperature in every July to investigate its long term variations and the anomalies in 2020. More information of this sea surface temperature data could be found from Kurihara et al. [8] and the following website: <http://ds.data.jma.go.jp/gmd/goos/data/pub/JMA-product>.

2.2 Wind data

National Centers for Environmental Predictions (NCEP) Reanalysis2 data provided by the NOAA/OAR/ESRL has been used to check the atmosphere status [9], which adopts the data assimilation using past data from 1979 through the previous year. This data uses global grids at varying resolutions and it is around $2.5^{\circ} \times 2.5^{\circ}$ in our focusing region. The available period is from 1979 until now. The data is available from their Web site at <https://psl.noaa.gov/>.

3 Results

3.1. Summer SST distributions

Figure 2 presents the sea surface temperature distributions over the East China Seas and the adjacent waters in July during the past 39 years (1982-2020). It suggests that the sea surface temperature in the study region is lower with latitude escalating during summer season. And it clearly shows that the horizontal heat transports of Kuroshio as well as the Taiwan-Tsushima warm current system [4][5]. In the northern area of the interesting region, the sea surface temperature is relatively lower than the southern

area, especially along the coast of the Korean Peninsula in the Yellow Sea.

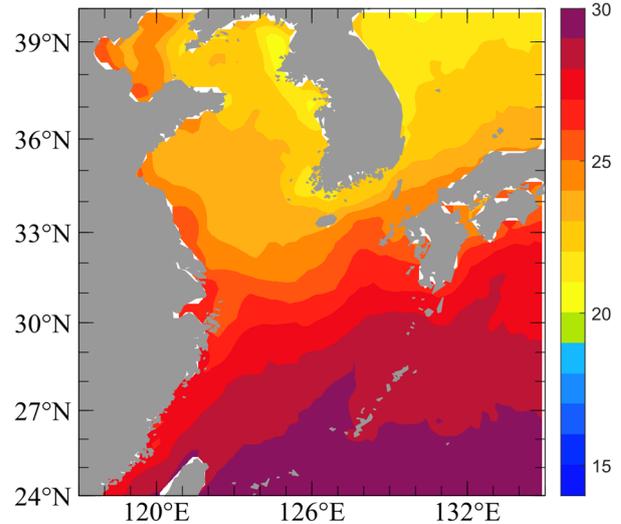


Fig2. Climatological (1981-2020) monthly mean sea surface temperature (SST) during July in the Yellow and East China Seas (Unit: °C).

As pointed out by the pervious study [11], the heavy rain (more precipitation) in the middle and lower reaches of the Yangtze River and the Huaihe River often has correspond to the lower sea surface temperature anomalies in the Yellow Sea and East China Sea in summer. In July of 2020, there were 6 times heavy rainfall processes in China, with an average rainfall of 157.5 mm, which is 8.8% more than that in the same period of the normal year. It is 57.2% and 31.6% more than that in the same period of the normal year along the Yangtze River Valley and the Huaihe River Valley, respectively [12]. Thus, we analysis the sea surface temperature of the East China Sea and its adjacent waters in the July of 2020.

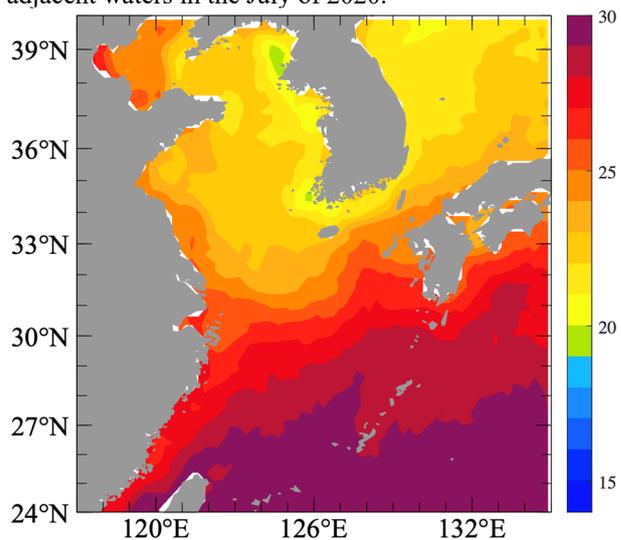


Fig3. Monthly mean sea surface temperature (SST) during July of 2020 in the Yellow and East China Seas (Unit: °C).

3.2 Summer SST anomalies of 2020

As demonstrated in Figure 3, the sea surface temperature of the East China Sea and its adjacent waters in the July of 2020 presents a larger horizontal gradient from the south to the north of China. Furthermore, the sea surface temperature anomalies in July of 2020 also has been checked in Figure 4. The sea surface temperature suggests strong cold anomalies in the Yellow Sea and the East China Sea, while it is warm anomalies in the Kuroshio region and Taiwan Strait. It is in accordance with the heavy rainfall phenomenon in the same period. As mentioned above, besides the surface heat flux, the horizontal heat transports of Kuroshio as well as the Taiwan-Tsushima warm current system has significant effects on the heat content in the East China Sea and its adjacent waters [5], which is mainly dominated by the wind forcing. Thus, the wind conditions are examined in the next section.

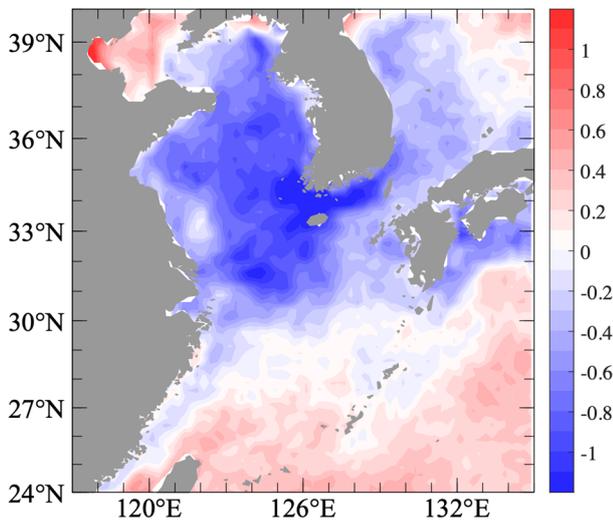


Fig4. Sea surface temperature (SST) anomalies during July of 2020 in the Yellow and East China Seas (Unit: °C).

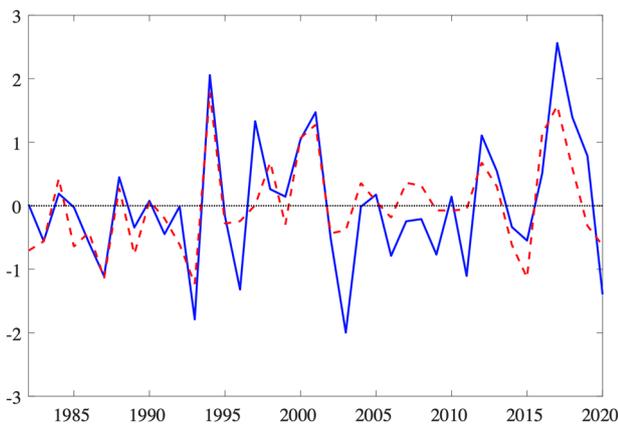


Fig5. Time series of area averaged sea surface temperature (SST) anomalies of July in the Yellow Sea (red line) and East China Sea (blue line).

4 Discussions

The time series of area averaged sea surface temperature anomalies of July in the Yellow Sea (red line) and East China Sea during recent ~40 years have been shown in Figure 5. After de-trend the sea surface temperature, we chose the area-averaged negative anomaly larger than 0.5°C as the colder summer years.

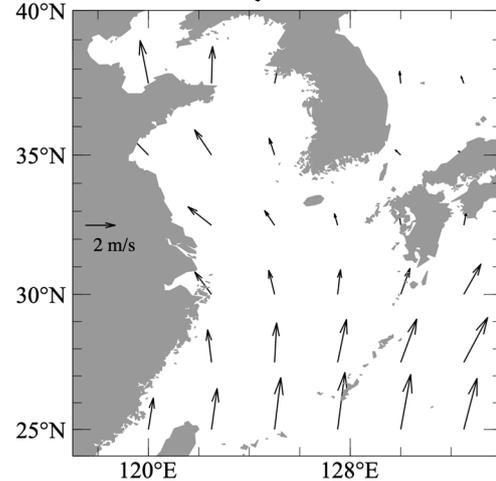


Fig6. Climatological (1981-2020) monthly mean wind during July in the Yellow and East China Seas.

The climatological summer southerly monsoon and the wind condition in the colder summer years over the East Asian have been illustrated in Figure 6 and Figure 7, respectively. Additionally, the wind anomalies of the colder summer years also has been presented in Figure 8. It suggests that in the colder summer year, there is an obviously stronger westerly anomaly wind component. The westerly wind anomaly seems to change the onshore intrusions of the high temperature Kuroshio water and the transport from Taiwan Strait. In other words, under the controlling of the strong westerly anomaly wind, the transport and the pathway of the Kuroshio might be modified, which leads to the less onshore intrusion of the warmer water.

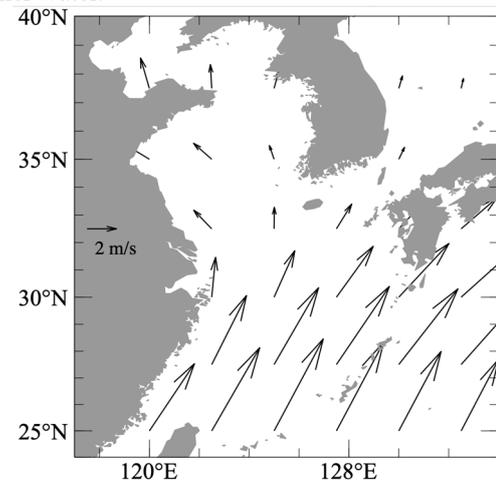


Fig7. Monthly mean wind during July of the colder year in the Yellow and East China Seas.

Further, as studied by Cui et al. [10], the low sea

surface temperature is helpful for a downward air motion with a convergence at near sea surface level. And it could lead to the enhance of the westerly wind anomalies. Thus, this study suggests that the feedback effects of the ocean in the local region also dominated on the heat content of the East China waters. Further quantitative studies are worth conducting.

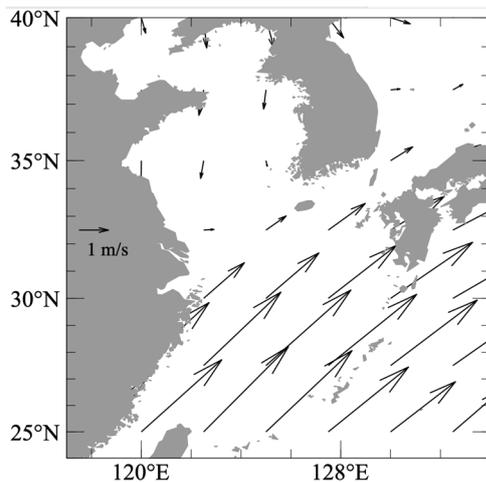


Fig8. Wind anomalies during July of colder in the Yellow and East China Seas.

5 Conclusions

Long term variations of sea surface temperature and its anomalies for the July of 2020 in the Yellow and East China Seas were investigated based on the Merged Satellite and In-situ Data Global Daily sea surface temperature provided by the Japan Meteorological Agency (JMA) using the methods of composite and correlation analyses. The results suggest, contrary to warming anomalies in the North-western Pacifica Ocean, the sea surface temperature in the East China Sea is cooler around 0.5°C and that in the East China Sea is cooler around 1.3°C than the normal values. The sea surface temperatures approach the extreme low value in the Yellow Sea and East China Sea in July, and warm up to the normal year in August. In addition, the south-westerly summer monsoon over this region, is proposed to contribute the transport of Kuroshio and its pathway. The obvious westerly wind anomalies, correspond to the lower sea surface temperature over the Yellow and East China Seas in July of 2020, leads to a clear less heat advection from Kuroshio to this region. Further, the low sea surface temperature, leading a downward air motion with a convergence at near sea surface level, is helpful for the enhance of the westerly wind anomalies until the strong surface heat flux in August. This study suggests that the local horizontal circulation advection and net heat flux are also dominated on the heat content of the East China waters. Further quantitative studies are worth conducting.

Acknowledgments

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References

1. Frankignoul C., Kestenare E. *Climate Dynamics*, 19(8): 633-647(2002).
2. Liu S., Wang H., Jiang H., Jin Q. H. Variation of sea surface temperature and its influence factors in the North Pacific. *Acta Oceanologica Sinica*, 2013, 35(1): 63-75(in Chinese).
3. Hirose N , Lee H C , Yoon J H . Surface Heat Flux in the East China Sea and the Yellow Sea[J]. *Journal of Physical Oceanography*, 1999, 29(3):401-417.
4. Hsueh Y , Lie H J , Ichikawa H . On the branching of the Kuroshio west of Kyushu[J]. *Journal of Geophysical Research: Oceans*, 1996, 101(C2).
5. Isobe A. The Taiwan-Tsushima Warm Current System: Its Path and the Transformation of the Water Mass in the East China Sea[J]. *Journal of Oceanography*, 1999, 55(2):185-195.
6. Yang D , Yin B , Chai F , et al. The onshore intrusion of Kuroshio subsurface water from February to July and a mechanism for the intrusion variation[J]. *Progress in Oceanography*, 2018, 167(OCT.):97-115.
7. Wu Lei, Wang Bin, Pan Xishan, Han Xue et al. Intercomparison analysis of merged Sea Surface Temperature products for the Bohai, Yellow and East China Seas, *Marine Science Bulletin* (accepted).
8. Kurihara, Y., T. Sakurai, and T. Kuragano. *Weather Service Bulletin, Special issue*, s1-s1873(2006), (in Japanese).
9. Kanamitsu M., Ebisuzaki, J. Woollen, S-K Yang, J.J. Hnilo, M. Fiorino, and W. G. L. Potter., *Bulletin of the American Meteorological Society*, 1631-1643, (11)2002.
10. Cui Rongshuo, Hongjian T , Ronghui H , et al. The Relationship between Interannual Variations of Summer Precipitation in Eastern China and the SST Anomalies in the East China Sea and Its Adjacent Seas, *Chinese Journal of Atmospheric Sciences*, 2012, 36(1):35-46.
11. *Bulletin of flood and drought disasters in China*, 2020